PERSISTENCE OF METSULFURON IN DIFFERENT SOILS

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SUMMARY

Dissipation of metsulfuron was investigated in four soil types in the Waikato after it was applied at 6, 12 or 18 g/ha in September or March. Soil samples collected from 0-5 cm depth the day after spraying and at weekly intervals thereafter were bioassayed in the glasshouse using seven bioassay species with varying sensitivities. Mustard (*Sinapis alba*) and subterranean clover (*Trifolium subterraneum*) were the most susceptible. Herbicide residual activity varied from 1 week to more than 9 weeks depending on species and soil type. Persistence was shorter in soils with lower pH and/or high organic matter. Phytotoxic residues lasted slightly longer in autumn/winter than in spring/summer.
Keywords: metsulfuron, soil type, persistence, residues, bioassay

INTRODUCTION

Several sulfonylurea herbicides have so far been developed, mainly for use in cereals, rice, soya beans and for non-selective industrial weed control. In New Zealand some of them have also been evaluated for control of certain difficult to kill weeds in pastures (Martin *et al* 1988; Rahman *et al* 1988; Rahman and Martin 1989) because of their non-hormone nature and their wide spectrum of activity. The herbicide tribenuron methyl was recently registered for spot treatment of pasture weeds such as ragwort (*Senecio jacobaea*) and certain thistles, but its performance has been variable.

The herbicide metsulfuron is currently registered in New Zealand for control of many woody and broadleaf weeds. Its use for selective control of pasture weeds is not practical, because it seriously damages both ryegrass and white clover (Popay *et al* 1985). However, such a product may have a place in situations where the pasture has to be replaced with a crop or a new pasture such as in pasture renovation or direct drilling of crops. If such an approach is to be adopted, the first and immediate question to be answered is the length of persistence of metsulfuron in the soil and its effect on the subsequent crop or pasture species to be planted.

Metsulfuron is known to have high soil activity and a relatively long residual life in the soil (Beyer *et al* 1988; Guenther *et al* 1989). Its principal modes of degradation are microbial breakdown and chemical hydrolysis, both of which are dependent on many factors and can vary widely between different soils (Beyer *et al* 1987). This study was designed to determine the residual activity of metsulfuron in different soils and to establish the time after which certain crop or pasture species can be planted in fields treated with this herbicide.

MATERIALS AND METHODS

Four field trials were conducted on established pastures in the Waikato. The soil types, some characteristics of the soils and the rainfall data for each site are presented in Table 1. The layout at each site was a split-plot randomised block design with four replicates. Individual plots were 5 m x 2 m. The herbicide treatments included glyphosate (Roundup) at 0.72 kg/ha alone and in combination with metsulfuron (Escort) at 6, 12 or 18 g/ha. These were applied with a precision sprayer delivering 300 litres/ha at 210 kPa.

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TABLE 1: Some soil properties and rainfall records of trial sites.

Soil type	Organic C (%)	pH	Rainfall (mm) Spring/summer 2 wk*	4wd	9wk	Autumn/winter 2wk	4wk	9wk
Hamilton clay loam	2.9	6.3	74	224	329	21	61	252
Horotiu sandy loam	6.0	5.7	74	224	329	21	61	252
Kakepuku sandy loam	10.4	5.4	39	133	240	5	30	175
Kaipaki peaty loam	22.8	5.2	45	129	271	1	22	201

*Total rainfall for the period from the date of application.

All four herbicide treatments were applied in the spring (late September) 1989 and also in the autumn (late March) 1990.

Soil was sampled (about 20 cores/plot to a depth of 5 cm) from each plot with a 7.5-cm diameter soil sampler for bioassay of herbicide residues. Using the day of treatment as day 0, soil samples were taken on days 1, 7, 14, 21, 28, 42 and 63 after treatment.

All soil samples collected from the field were bioassayed in the glasshouse using mustard, subterranean clover and sorghum (*Sorghum bicolor*). Oats (*Avena sativa*) and maize (*Zea mays*) were also included as the test species for the spring/summer bioassays while annual ryegrass (*Lolium multiflorum*) and red clover (*Trifolium pratense*) were the additional species in the autumn/winter bioassays. Soil samples from each plot were mixed thoroughly and then used to plant out the bioassay species into 11-cm diameter pots. These were grown in the glasshouse for 4-5 weeks before they were assessed for visual damage and harvested for dry matter determinations. Further details of the bioassay procedure have been described by Rahman (1989).

For comparative purposes a series of standards was run with all bioassay species in the glasshouse at different times of the year, by employing a range of concentrations of metsulfuron between 0.5 and 100 μg/kg oven-dry soil. The herbicide was thoroughly mixed with the soil before planting out various bioassay species. All treatments were replicated four times. Pots were sub-irrigated to maintain the soil moisture near field capacity. The plants were assessed visually and harvested after 4-5 weeks growth to determine the dry matter weight of shoots.

RESULTS AND DISCUSSION

Glasshouse standards

The effects of known concentrations of metsulfuron (standards) on six bioassay species in the glasshouse in Hamilton clay loam soil are presented in Fig. 1. These data are based on the average of four series of standards planted between July 1989 and May 1990. Mustard was the most susceptible species to this herbicide followed closely by subterranean clover and red clover. Sorghum was only slightly less susceptible than these three species during winter but was much less sensitive during spring/summer, probably because of much better growing conditions for this species. Maize was the most tolerant species of those included in Fig. 1. Data for oats are not included here because they did not show any significant reduction in growth until the concentration reached 50 μg/kg or more.

To investigate the effect of soil type on the biological activity of metsulfuron, standards were established with all test species in the four soils used in this study. Dry matter weights of mustard (Fig. 2) show that the activity of metsulfuron through the soil was higher (or the DM as percentage of untreated was lower) in the Hamilton clay loam and Horotiu sandy loam soils than the other two soil types. The magnitude of this difference varied with the bioassay species, but the trend was similar in all cases. The visual damage data reflected well the actual dry matter reduction from various treatments. As seen from the data on soil properties in Table 1 there are large differences between the four soils in their organic C content, pH and their texture. All these characteristics are known to influence the biological activity of metsulfuron in the soil (Beyer *et al* 1987).

Fig. 1: Effect of different concentrations of metsulfuron on bioassay species in the glasshouse (standards).

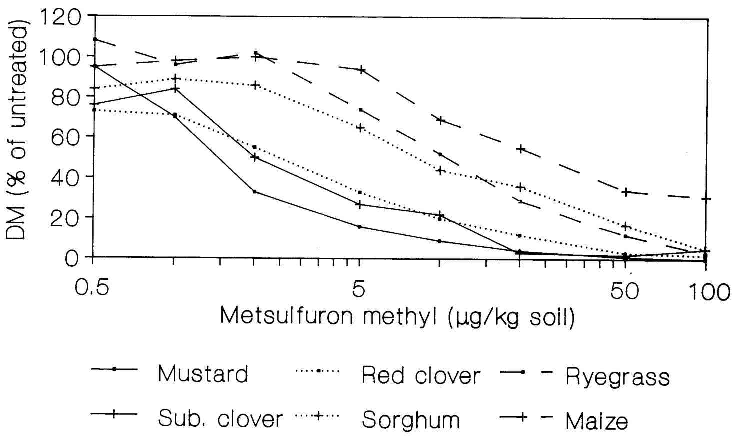
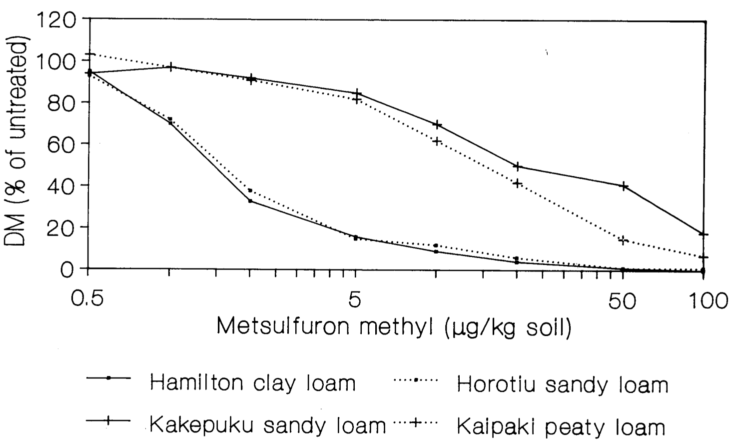


Fig. 2: Biological activity of metsulfuron (DM of mustard) in four soil types in the glasshouse.

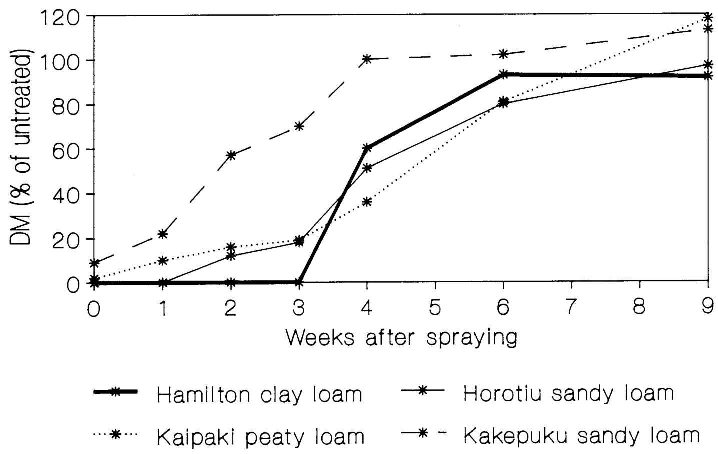


Glasshouse bioassays

As was the case with the biological activity in the 'standards' experiments, the persistence of metsulfuron in the field also varied between the four soils. These differences were greater in the autumn than in the spring and were more obvious in the first few samplings.

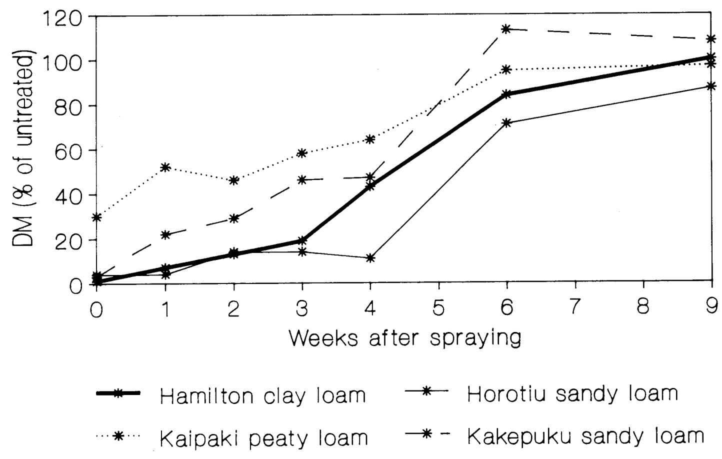
For the spring application of the 12 g/ha rate the DM yield of mustard (relative to untreated controls) was higher (showing lower residual activity) in the Kakepuku sandy loam soil than the other three soils (Fig. 3). Residues of metsulfuron from this application rate (a rate suggested for control of weeds such as ragwort and thistles) were still present in sufficient quantities to cause significant reductions in the growth of susceptible species for between 6 to 9 weeks after treatment depending on the soil type. No phytotoxic residues were detected by oats after 1-2 weeks and by maize 3-4 weeks after application.

Fig. 3: **Bioassay results (DM of mustard) of the residual activity of *spring-applied* metsulfuron (12 g ai/ha) in four field trials. The average SEM values for the four soils are 1.3, 3.7, 9.6, 10.8, 10.9, 16.4 and 21.2 for weeks 0 to 4, 6 and 9 respectively.**



The differences in the residual activity between soils, as demonstrated with mustard, were larger in the autumn/winter months (Fig. 4), but they followed similar trends to that observed for the spring application (Fig. 3). Growth reductions of all bioassay species were generally greater for a longer period in the winter bioassays, suggesting a slightly longer persistence compared to the spring application. Thus residues from the 12 g/ha autumn application were still causing growth reductions between 6 and 9 weeks after application. Lower temperatures and rainfall in

Fig. 4: **Bioassay results (DM of mustard) of the residual activity of *autumn-applied* metsulfuron (12 g ai/ha) in four field trials. The average SEM values for the four soils are 2.3, 6.1, 6.7, 8.1, 12.6, 14.8 and 16.3 for weeks 0 to 4, 6 and 9 respectively.**



autumn/winter compared to the spring/summer are probably responsible for the slightly longer persistence of the autumn application. A decrease in temperature or moisture has been shown by several workers to slow the rate of detoxification of sulfonylurea herbicides (e.g. Beyer *et al* 1988).

A summary of the length of persistence of each rate based on dry matter yields of different bioassay species is presented in Table 2. This summary covers the results from all the four trial sites.

TABLE 2: Approximate range of persistence (in weeks) of phytotoxic residues of metsulfuron in the four soils.

	6 g ai/ha		12 g ai/ha		18 g ai/ha	
Bioassay species	spring	autumn	spring	autumn	spring	autumn
Mustard/sub clover	4-6	4-6	6-9	6-9	9	>9
Sorghum	2-4	4	4-6	6	6-9	6-9
Maize	2-4	*	3-4	*	3-4	*
Ryegrass	*	2-4	*	4-6	*	4-9
Oats	1	*	1-2	*	1-3	*

*Not included

The visual observations in general supported the trend shown by the data on dry matter yield. However, in most cases the visual damage symptoms were noted for a week or two longer than the dry matter yield reductions, suggesting that the damage to foliage did not translate into a significant growth suppression. This was especially obvious in the case of sorghum and mustard where minor damage symptoms in the form of leaf shape and colour could be observed for quite some time without any obvious effects on plant growth and development.

During both the spring and autumn trials the persistence of metsulfuron in the Kaipaki peaty loam and Kakepuku sandy loam soils was often 2-3 weeks less than in the Hamilton clay loam or Horotiu sandy loam soils for most of the bioassay species. The Kaipaki and Kakepuku soils had much higher levels of organic matter and a lower pH than the other two soils. Both of these traits enhance the degradation of sulfonylurea herbicides and thus reduce their persistence (Beyer *et al* 1987; Rahman 1989).

Soil moisture is another major factor which determines the rate of degradation both through chemical hydrolysis and microbial processes (Beyer *et al* 1988). The Hamilton clay loam and Horotiu sandy loam sites received higher rainfall in both summer and winter months than the two other sites and this should have resulted in reduced persistence of the herbicide. It appears, however, that the large difference in soil characteristics affected the persistence of metsulfuron between sites more than the difference in rainfall recorded here (Table 1).

In conclusion, the data presented here show that metsulfuron could be useful for pasture renovation or direct drilling situations. Following autumn application of rates required for effective control of weeds such as ragwort, a waiting period of up to 9 weeks would be required before a pasture could be re-established successfully. However, if used in the spring, a more tolerant crop such as oats or maize could be planted within 2 or 4 weeks of application respectively and a pasture could then be established in the autumn.

The persistence of this herbicide was shorter in soils with lower pH and/or high organic matter. The soil characteristics would therefore be an important consideration in deciding this 'waiting period', as could be the weather conditions of the particular year. Further work would be required to establish the length of persistence in other parts of the country.

REFERENCES

Beyer, E.M., Brown, H.M. and Duffy, M.J., 1987. Sulfonylurea herbicide — soil relations. *Proc. 1987 British Crop Protection Conference — Weeds:* 531-540.

Beyer, E.M., Duffy, M.J., Hay, J.V. and Schlueter, D.D., 1988. Sulfonylurea herbicides. *In:* Kearney, P.C., Kaufman, D.D. (eds), Herbicides: Chemistry, Degradation and Mode of Action. Marcel Dekker Inc, New York. 3: 117-189.

Guenther, P., Rahman, A. and Pestemer, W., 1989. Quantitative bioassays for determining residues and availability to plants of sulfonylurea herbicides. *Weed Research 29:* 141-146.

Martin, P., Thompson, A. and Rahman, A., 1988. Spot treatment of ragwort and nodding thistle with DPX-L5300. *Proc. 41st N.Z. Weed and Pest Control Conf.:* 223-225.

Popay, A.I., Cornwell, M.J. and Rahman, A., 1985. Effects of metsulfuron on pasture. *Proc. 38th N.Z. Weed and Pest Control Conf.:* 102-105.

Rahman, A., 1989. Sensitive bioassays for determining residues of sulfonylurea herbicides in soil and their availability to crop plants. *In:* Munawar, M. *et al* (eds), Environmental Bioassay Techniques and Their Application. *Hydrobiologia 188/189:* 1367-375.

Rahman, A. and Martin, P., 1989. Pasture tolerance to spring applications of the herbicide thiameturon methyl. *Proc. 42nd N.Z. Weed and Pest Control Conf.:* 35-38.

Rahman, A., James, T.K. and Mortimer, J., 1988. Persistence and mobility of the sulfonylurea herbicide DPX-L5300 in a New Zealand volcanic soil. *Mededelingen van Rijksfaculteit Landbouwwetenschappen Gent 53:* 1463-1469.